Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

sunset on August 31st. It comes to opposition with the Sun on August 23rd, and is then above the horizon the entire night. It moves about 2° westward in the constellation *Aquarius* during the two months.

Neptune reaches conjunction with the Sun on August 2nd, changing from an evening to a morning star.

THE BINARY STARS[1]. A REVIEW

By E. E. Barnard

The best contribution to the general literature of double stars in recent years is the admirable volume on the subject by Robert Grant Aitken of the Lick Observatory. The presentation of this work has fallen into worthy hands indeed and the result is a book that can be read with much pleasure as well as with profit.

Professor Aitken has given us a work which is not only of permanent value for instruction but is of very deep interest because of the historical information it contains. It will be valuable to the general astronomical reader, as it gives an interesting account of the early history and development of double-star work. To the double-star observer himself it is an excellent source of information concerning the first observers of these stars, about whom he has probably known little enough. Perhaps even some of the regular double-star observers will be surprised to learn how slow the earlier astronomers were to grasp the nature and importance of these objects.

The first double stars discovered, such as α *Centauri*, *Castor*, etc., were, as would be supposed, found by accident. It is with surprise, however, that we read of the subsequent treatment of these most interesting and important bodies by the early observers. To them a double star was simply two stars seen nearly in the same line of sight and not physically connected in any way and probably vastly distant from each other. Especially was this thought to be the case where one of the stars was brighter than the other. This strange lack of insight into their true nature continued for upward of a hundred years after the first discoveries were made. A strong interest was taken in them, however, and they were sought for and

[1]Robert Grant Aitken, *The Binary Stars*, 1918, 316 pages. Douglas C. McMurtrie, 2929 Broadway, New York. Price $3.15.

carefully observed, not with the belief that they were physically connected (indeed, it was necessary that they should have no physical connection whatever), but with the hope that their measurement offered the best means of determining stellar parallax. Even Herschel made a special search for these stars, at first with no other idea of their importance than for the determination of stellar parallax.

The first double stars discovered were γ *Arietis* in 1664 and α *Crucis* and α *Centauri* in 1685 and 1689 respectively. It was not until 1767, however, when it was shown by John Michell that such stars were probably physically connected systems, that they became of general interest as double stars.

It was in the latter part of the eighteenth century that thru the investigations of Christian Mayer, who formed the first catalog of double stars, and of Sir William Herschel, who could not remain long in error, that these stars were ultimately recognized as physically connected systems. Herschel was finally convinced by his own measures that they were actually physically connected, for in his observations he found that in some cases there really was a change in the relative positions, but not such as would be due to parallax. Thus, after great delay, the true nature of these objects became known and their intelligent study as double stars began. They were now sought for and observed for the investigation of their motions about each other. The fallacy of their observation for parallactic displacement was at last recognized.

Professor Aitken pays a fine tribute to Burnham and the work that was done with the six-inch Clark refractor, work which in many ways was revolutionary in the fact that it showed that there was no end to the discovery and observation of double stars, even with the limited means at his disposal. We learn that after the discovery of new double stars seemed exhausted with much larger instruments, Burnham discovered 451 new pairs with the famous six-inch Clark refractor and set a record of the highest order, which he maintained in all the subsequent work that he did with this instrument and the greater telescopes which he used later on.

It is pleasant reading to learn of the great work in double-star astronomy by those who preceded Burnham, and by those who were his contemporaries. Such men as the Herschels, the Struves, Dawes, Hough and others, and especially Dembowski, to whose skill and help Professor Burnham bears loving testimony in one

of his books, were among the men who built up a solid foundation for the double-star astronomy of today. It is almost pathetic to learn of the trials of the earlier observers, who were so seriously handicapped for the want of proper equipment with which to carry on their chosen work. One of these men was Baron Dembowski, who worked with a five-inch telescope with no driving clock or means of determining position angles (which he derived from measures of differences of right ascension and declination) until 1859, when he obtained a seven-inch refractor, fully equipped with micrometer and driving clock.

It appears that Wilhelm Struve in 1824 was the first observer to actually use clockwork for driving his telescope, tho it seems that a telescope driven by a clock was presented to the king of France in 1757, who doubtless did not sit up to verify the statement that "it would follow a star all night long."

Chapter III contains a discussion of the best methods of observing, which is of special value coming from one with such a wide and successful experience with the micrometer. The method of determining the parallel, the value of a revolution of the micrometer screw and the best way of observing double stars are successively given, with an example of the method of recording the observations, the best form of observing book, etc. When observing position angles the author finds that where the angular distance is small or the stars differ much in brightness, it is best to bisect the stars with a single movable wire instead of placing them between two wires close together, as some observers prefer to do. He emphasizes the importance of using only good nights for observing double stars, as observations made on poor nights often lead to annoyance and error.

It is recommended that instead of estimating the actual magnitudes of the components of a double star, their difference of magnitude be recorded, which seems a very satisfactory method and subject to greater exactness. The actual magnitude of each star can then be determined from the catalogued magnitude of the brighter one or of the combination.

An interesting discussion of the separating power of a telescope is given. After discussing the results obtained by Lewis, using Dawes' formula

$$\text{Separating power} = \frac{4''.56}{a\ \text{(aperture in inches)}}$$

Aitken finally, from measures by Burnham, Hussey and himself, deduces the following formula for the thirty-six-inch refractor.

Equal bright pairs $\dfrac{4''.3}{a}$, mean magnitudes 6.9 and 7.1.

Equal faint pairs $\dfrac{6''.1}{a}$, mean magnitudes 8.8 and 9.0.

His experience, however, is that under ordinary observing conditions, the angular separation of the pairs measured should be nearly double the theoretical limit.

His remarks on diaphragms are interesting. He does not find that a diaphragm improves a good object glass and the views of both Schiaparelli and Burnham are opposed to the reduction of aperture. Really, tho Professor Burnham did not believe in reducing the aperture of the object glass, he often used a small diaphragm over the eyepiece, thus cutting down the beam before it entered the eye. This is a method that is often very useful in reducing the glare about a star. A discussion arose some time ago over this question as to whether a diaphragm over the eyepiece caused a reduction in the separating power of the object glass. I believe the question has never been definitely settled, tho it would seem, since the reduction of the beam of light occurs after the image is really formed, that it would not necessarily affect the separating power.

Valuable information is given with respect to the use of eyepieces. Professor Aitken's experience with thirty-six inch shows that it is better to employ low powers when the conditions are poor, for every increase of power increases the bad effects of poor definition. With respect to the best magnifying powers to use on the large refractor he says, "With the thirty-six-inch telescope my own practice is to use an eyepiece magnifying about 520 diameters for pairs with angular separation of 2″ or more. If the difference is only 1″, I prefer a power of 1000 and for pairs under 0″.5, I use powers from 1000 to 3000 according to the angular distance and conditions. Closeness and brightness of the pair and the quality of the definition are the factors that determine the choice. Very close pairs are never attempted unless 1500 or higher powers can be used to advantage."

Systematic errors of observation—especially in position angle—are treated of and suggestions offered for their elimination. The

method employed in some experiments by MM. Salet and Bosler in 1908 with a small total reflecting prism between the observers' eye and the eyepiece seems to satisfactorily eliminate systematic error in the observed position angle. The error seems to be greater when there is a considerable difference in the magnitudes of the two stars, tho the position with respect to the horizontal, even with stars of equal magnitude, is a source of error. In this connection it may not be out of place for the reviewer to give here an account of some experiments recently made by him with the forty-inch telescope of the Yerkes Observatory. The double star, Krueger 60, consists of two stars which differ by about one and a half magnitude. At present their relative position is such that when east of the meridian the small star is uppermost and when west it is the lower of the two. The star was observed on seventeen nights in the fall of 1916, both east and west of the meridian, in immediate succession on the same night. The distance between the components at the time was less than $2''.5$. On each occasion the stars were carefully placed (by turning the head) so that when bisected the two were exactly in the vertical to the line between the eyes, a precaution that should always be taken and which tends to diminish the systematic error in such observations. Following are the results:

East of Meridian (Small star up)	West of Meridian (Small star down)
P.A. $62^\circ.55$ (17 nights)	P.A. $62^\circ.71$ (17 nights)

The difference is $(U-D) = -0^\circ.16$. The different sets were discordant in some cases by as much as 1° to $1\frac{1}{2}^\circ$. When the proper precautions are taken (at least in the case of the present observer) there does not seem to be any serious error in the bisections for position angle, whether the small star is above or below, for the above difference is too small to mean anything. The measures seem to be easier when the small star is the lower. In respect to the question whether in bisecting the stars for position angle the line between them should be perpendicular to the line between the eyes or parallel with it: the reviewer finds that his measures are more consistent and easier when the stars are in the vertical line.

An interesting result is shown by comparing the measures of distances with the twelve-inch and the thirty-six inch telescopes. It appears that with the smaller instrument the measures of close

stars give larger distances, while with distances of 4″ or more this difference disappears.

A short discussion of the results of photographic measures show much in favor of the method for exactness where the conditions of distance and relative brightness of the components are favorable. But the closer pairs and those where much difference of magnitude exists, are not suitable for photographic measurement.

Chapter IV is devoted to a valuable description of the methods of determining the orbits of binary stars. A completely worked-out example is given in the case of the binary star, *Aitken 88*. This should be of very great help to the beginner in such work. The methods suggested and employed by Moulton, Comstock, Russell and others are discussed.

Chapter VI, in like manner, gives a full statement of the method of determining the orbits of the spectroscopic binaries from their radial velocities.

A brief account is given of the systems where one component is invisible, the two most famous examples of which are *Sirius* and *Procyon*, whose companions were subsequently discovered visually by Clark and Schaeberle respectively. Other dark companions, to *β Orionis*, *α Hydrae*, *α Virginis*, *ζ Cancri* and others, have been suspected to exist but so far they have not been found.

Chapter IX is devoted to a most interesting description of binary systems of special interest, including *α Centauri*, whose orbits by Roberts, See, Doberck and Lohse are in good accord. Thru the measures of the radial velocity by Wright in 1904 and the known elements of the orbit, Wright has determined the parallax of this system and gets results in close accord with direct determinations of its parallax.

In Chapter X Professor Aitken gives an important statistical study of the distribution of the visual double stars in the northern sky, which contains a number of tables showing the distribution of these stars by magnitudes, by angular distances, by spectral types, etc.

An important chapter (XI) contains a valuable discussion of the various theories of the origin of the binary stars. Professor Aitken finally concludes that when everything is considered, the fission theory of their origin is, perhaps, the most satisfactory, tho there are very serious difficulties about accepting it without reserve.

One of the most interesting and instructive parts of this most interesting book is that contributed by Dr. J. H. Moore on the radial velocity of a star. This is very clearly written and to those who are not familiar with the work of the spectroscope is of the utmost value. One statement that makes more evident the difficulties that beset this wonderful instrument—the spectroscope—is that "When stellar spectrographs of three prism dispersion are used in conjunction with large refractors or reflectors, the combined instrument delivers to the photographic plate probably less than two per cent. of the light incident upon the telescope objective." Yet, with all the drawbacks that are so clearly set forth in Dr. Moore's valuable article, results that seem almost like magic are obtained when all the multitudinous precautions are taken into account. It is a happy combination indeed that places before the reader two such splendid accounts of the results of visual and spectroscopic observations of the binary systems of stars. When one has read Dr. Moore's account of the sources of error in the spectroscope and the ingenious devices that have been brought to bear upon their prevention or elimination, one can but express the sincerest admiration for the work of those who have made the spectroscope the magician's wand that it now seems to be.

Yerkes Observatory, E. E. BARNARD.
Williams Bay, Wisconsin,
May 15, 1919.

PAPERS AND ABSTRACTS OF PAPERS TO BE PRESENTED AT THE MEETING OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC AT PASADENA, JUNE 19-20, 1919.

As already announced in these PUBLICATIONS, the Astronomical Society of the Pacific will meet with the Pacific Division of the American Association for the Advancement of Science at Pasadena, on June 19-21. Two sessions will be held for the presentation of scientific papers, both at Throop College, the first from 10 to 12 on Thursday morning, June 19th, the second from 9:30 to 12 on Friday morning. At the second session a number of papers of interest to physicists as well as astronomers will be read and the members of